PHY 201 Homework 7

Due Friday, Oct. 18 at SE 316 at noon.

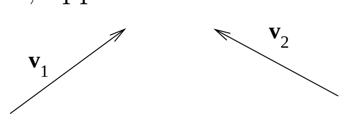
Some portions of this assignment involves reading material found on the Internet. Links to the web pages you will need can be found at `www.geneva.edu/~bvds/phy201`.

1. Read about Emmy Nöther and her theorem and answer the following questions:
   (a) What was Nöther's *main* interest as a Mathematician? (Give a one or two sentence reply.)
   (b) What was the great unsolved physics problem that motivated Nöther's theorem? About what time did she come up with this theorem?
   (c) What was the title (in German) of the paper where she explained the connection between symmetries and conservation laws?
   (d) Who said, "After all, the university senate is not a bath house!" Why did they say this? Explain the situation.
   (e) When and where did Emmy Nöther die? How old was she? What caused her death?

2. Go to the web pages by Chris Hill and Leon Lederman and read Sections II, III, and V.
   (a) What are the two basic kinds of symmetry? For each type, give your own example (don't use something from the web pages) of something that has that kind of symmetry.
   (b) The concept of an "event" is introduced. How many numbers do I need to specify an event?
   (c) Who is the third dumbbell and what is he demonstrating?
   (d) They use an example of a water tower to discuss what happens when external forces (gravity, in this example) are no longer time translation invariant. Can you come up with an analogous example for spatial translations?

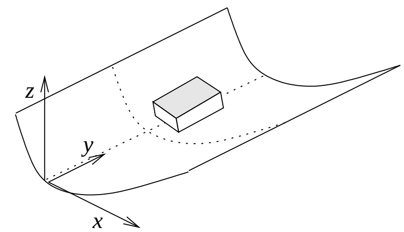
3. Two cars on an airtrack, each of mass m, collide. The first car has velocity v_1 and the other is at rest, $v_2 = 0$.
   (a) Use conservation laws to find the final velocities of the cars in the case of *elastic* collisions.
   (b) Use conservation laws to find the final velocity in the case where the two cars stick together. How much of the kinetic energy, in percent, is lost in this collision?

4. Two particles, each of mass m, approach each other with velocities $\mathbf{v}_1$ and $\mathbf{v}_2$.

   When they collide, they stick together. Using conservation of momentum, show that the change in the total kinetic energy is $m(\mathbf{v}_1 - \mathbf{v}_2)^2/4$.

5. Consider a block of ice sliding around in a very long U-shaped trough. Since the ice is slippery, the forces of friction can be ignored.



We will assume that the motion in the x-direction is pretty small and approximate the height of the trough in the x-direction as $z = \alpha x^2$. In this limit, one can also use small-angle approximations, $\sin(\theta) \approx \tan(\theta) \approx \theta$.

(a) Draw a diagram showing the forces acting on the block of ice.

(b) Using $\mathbf{F} = m\mathbf{a}$, write down the x- and y-components of the equation of motion. Express your answer in terms of $x(t)$ and $y(t)$. Any acceleration in the z direction is small and can be neglected.

(c) Are the equations of motion invariant under reflections about the yz-plane? $x \to -x$, $y \to y$, $z \to z$.

(d) Are the equations of motion invariant under reflections about the xz-plane? $x \to x$, $y \to -y$, $z \to z$.

(e) Are the equations of motion invariant under translations $\mathbf{x} \to \mathbf{x} + \mathbf{c}$?

(f) Are the equations of motion invariant under translations $\mathbf{y} \to \mathbf{y} + \mathbf{c}$?

(g) Are the equations of motion invariant under time translations $t \to t + c$?

(h) Using Nöther's theorem, is Energy conserved? Is momentum conserved?

(i) Write any conserved quantities as functions of the coordinates and the velocity.

6. A spring that obeys Hooke's law has a relaxed length of 12 cm and a spring constant of 60 N/m. It is placed on the floor in a vertical position and compressed to half its length. A 50 g ball is placed on top of the spring. The spring is released and the ball shoots straight up into the air. What maximum height above the floor does the ball reach? Use energy conservation to solve this problem. You should introduce variables for the spring constant *et cetera*.